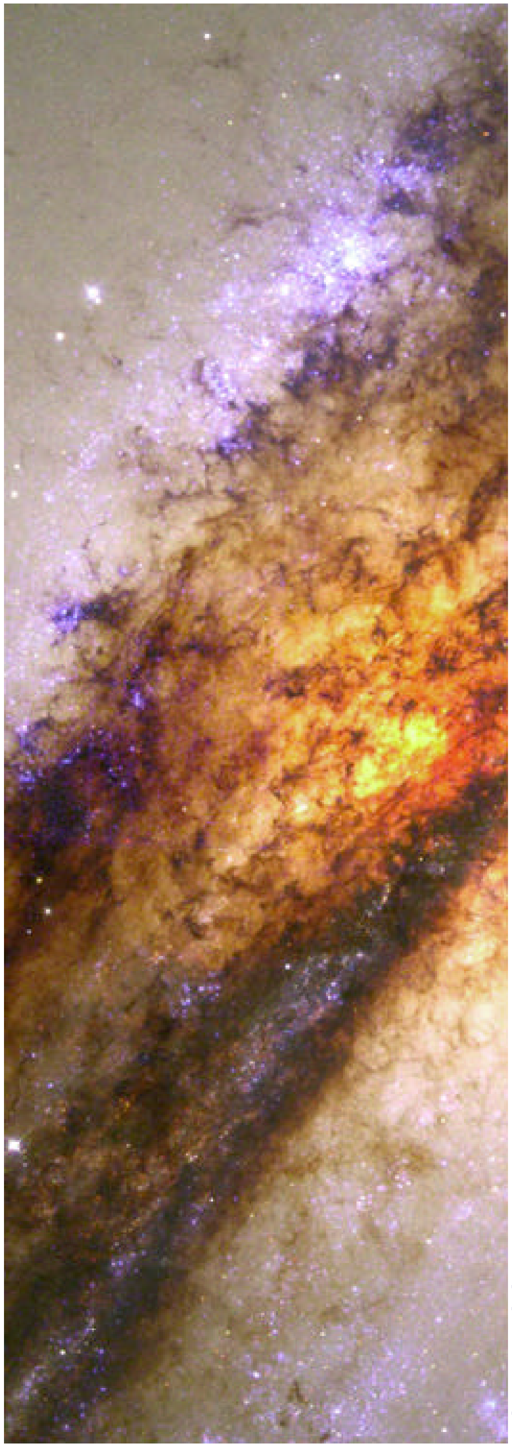
Next Generation Space Telescope (NGST)



Galactic Cannibalism, Centaurus A

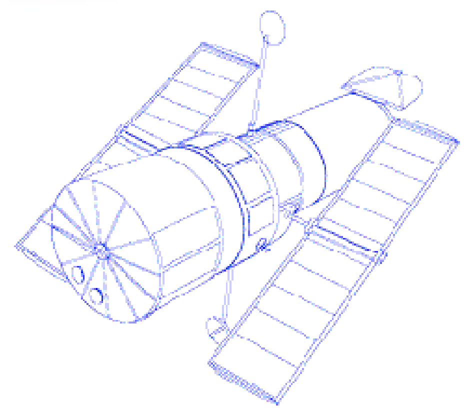
Presented by

John C. Mather
Project Scientist

NGST At a Glance

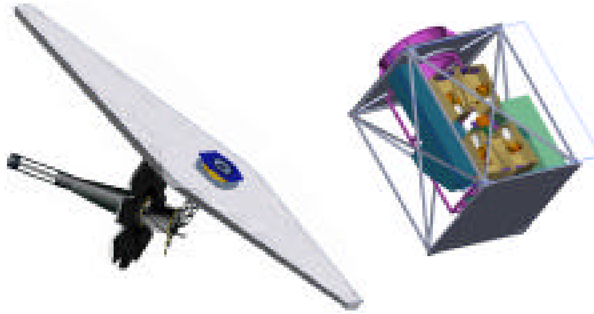
- **8m primary mirror**
- **0.6-28 µm wavelength range**
- **5 year mission life (10 year goal)**
- **passively cooled to <50K**
- **L2 orbit**
- **3 Core instruments**
  - **0.6-5 µm camera**
  - **1-5 µm Multiobject Spectrometer**
  - **5-28 µm camera/spectrometer**
- **2009 launch**

- Logical successor to HST
- Key part of the Origins Program



Strategic Partnerships

European Space Agency

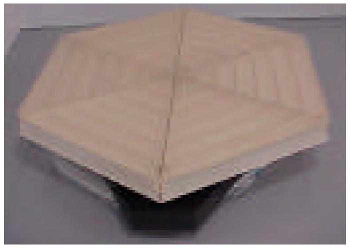


15% Observing Time

Canadian Space Agency

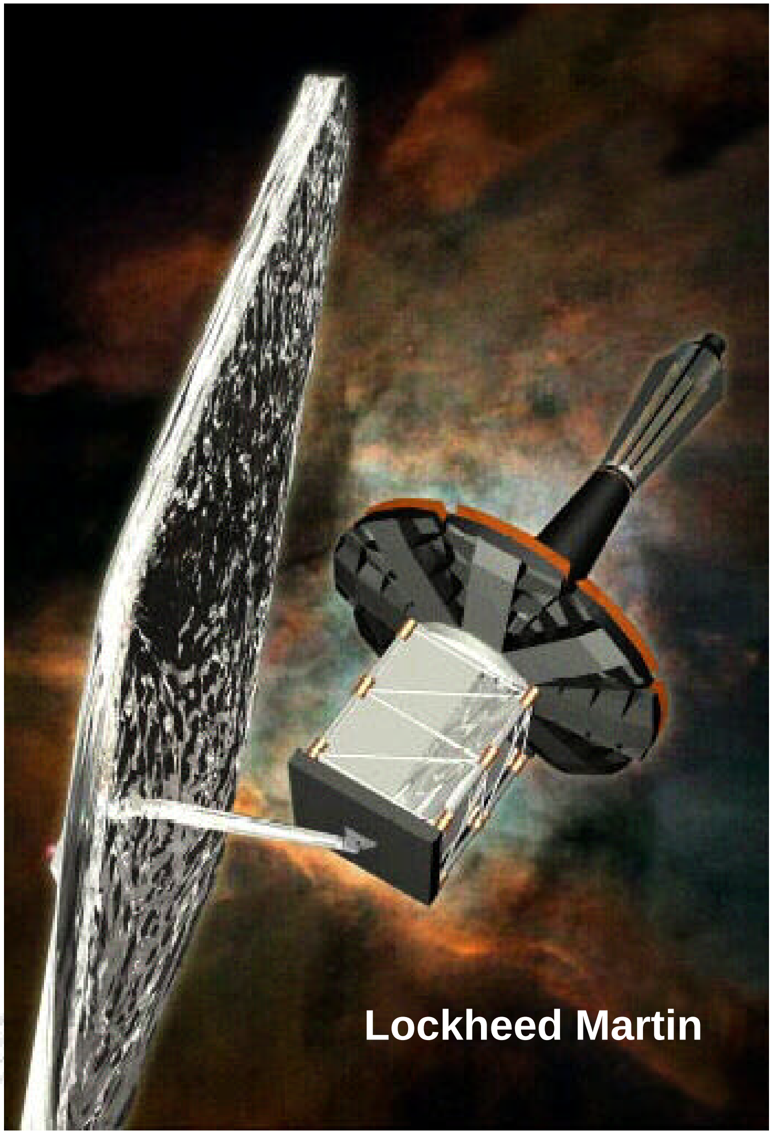
5% Observing Time

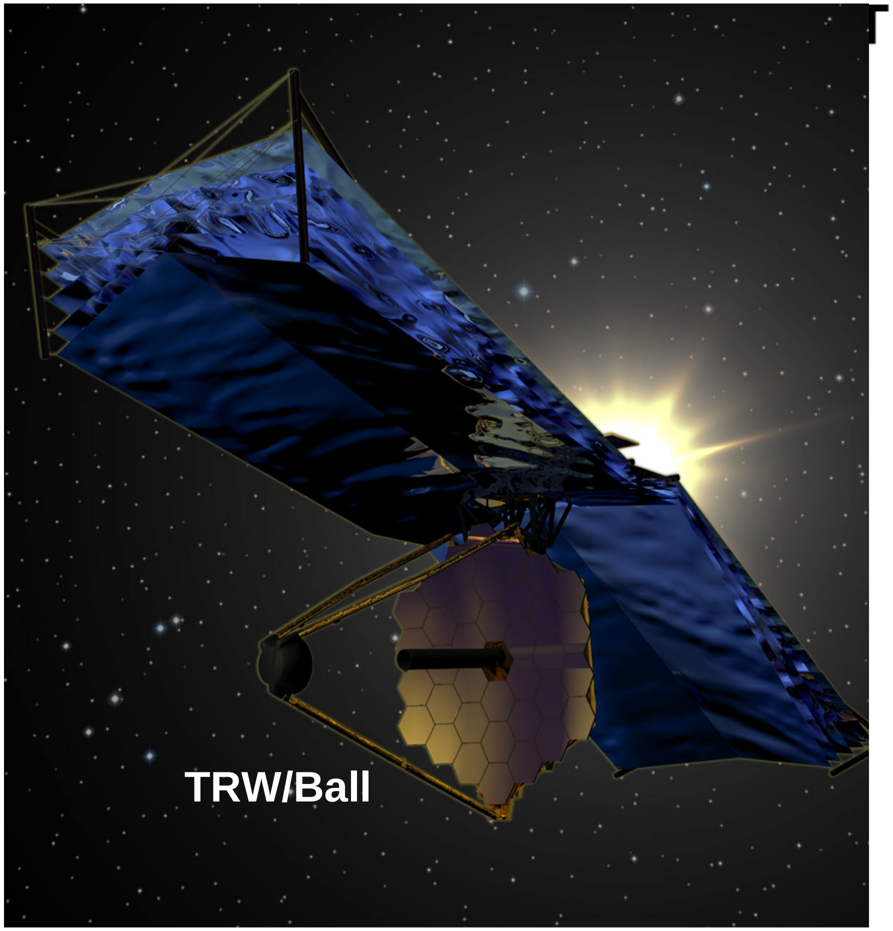
Department of Defense



Lightweight Mirror Technologies

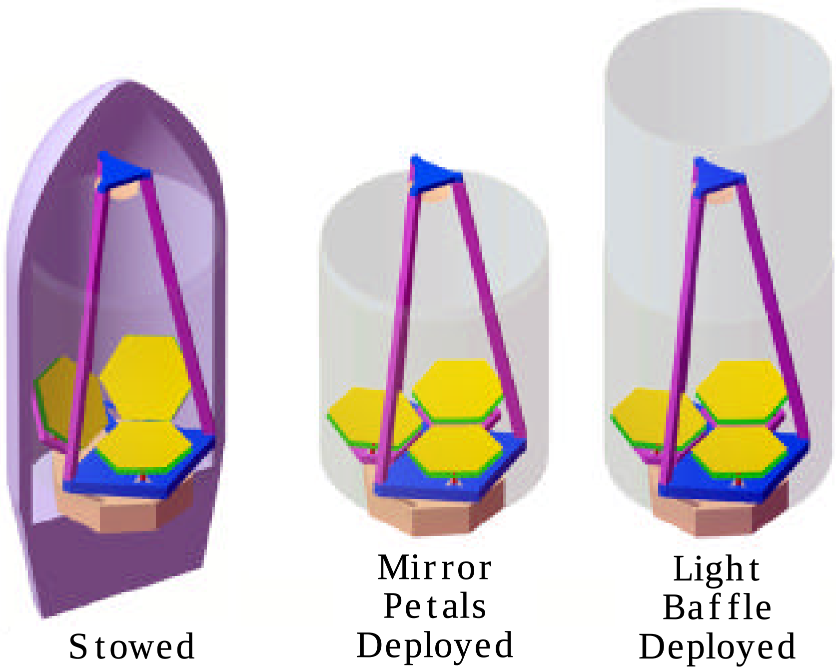
NGST Selects Lockheed and TRW for Phase 1

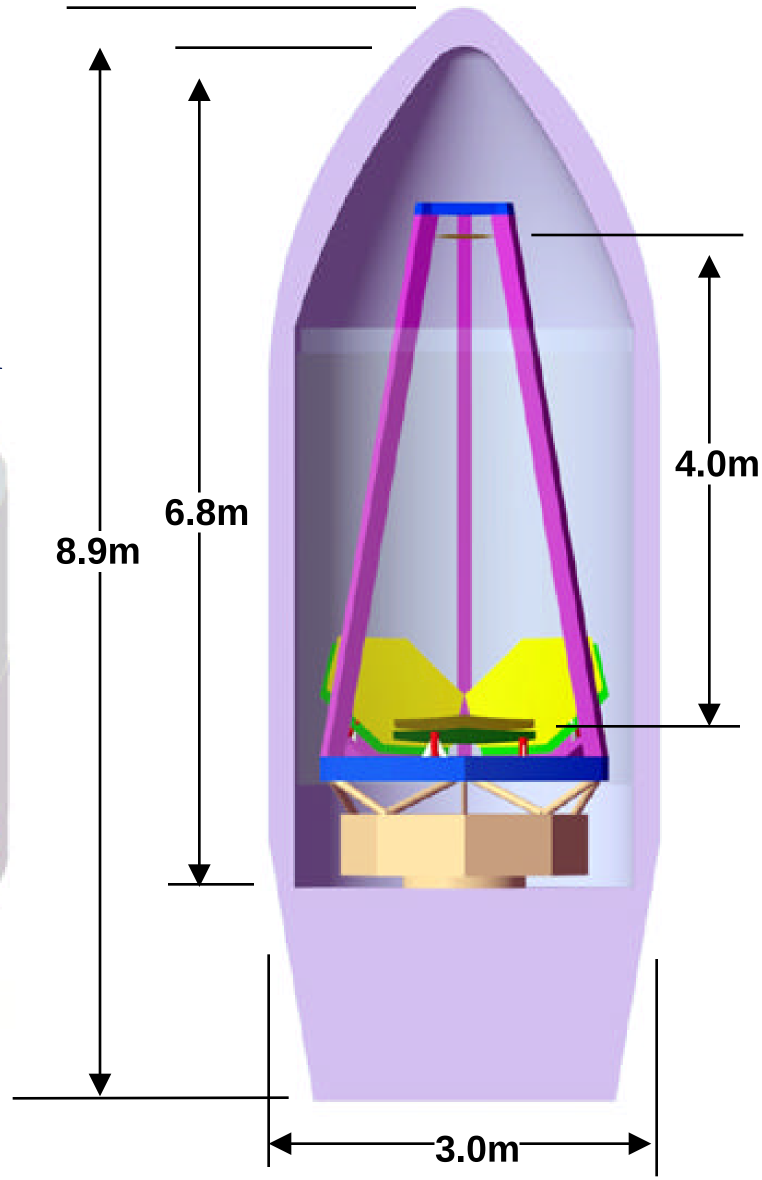




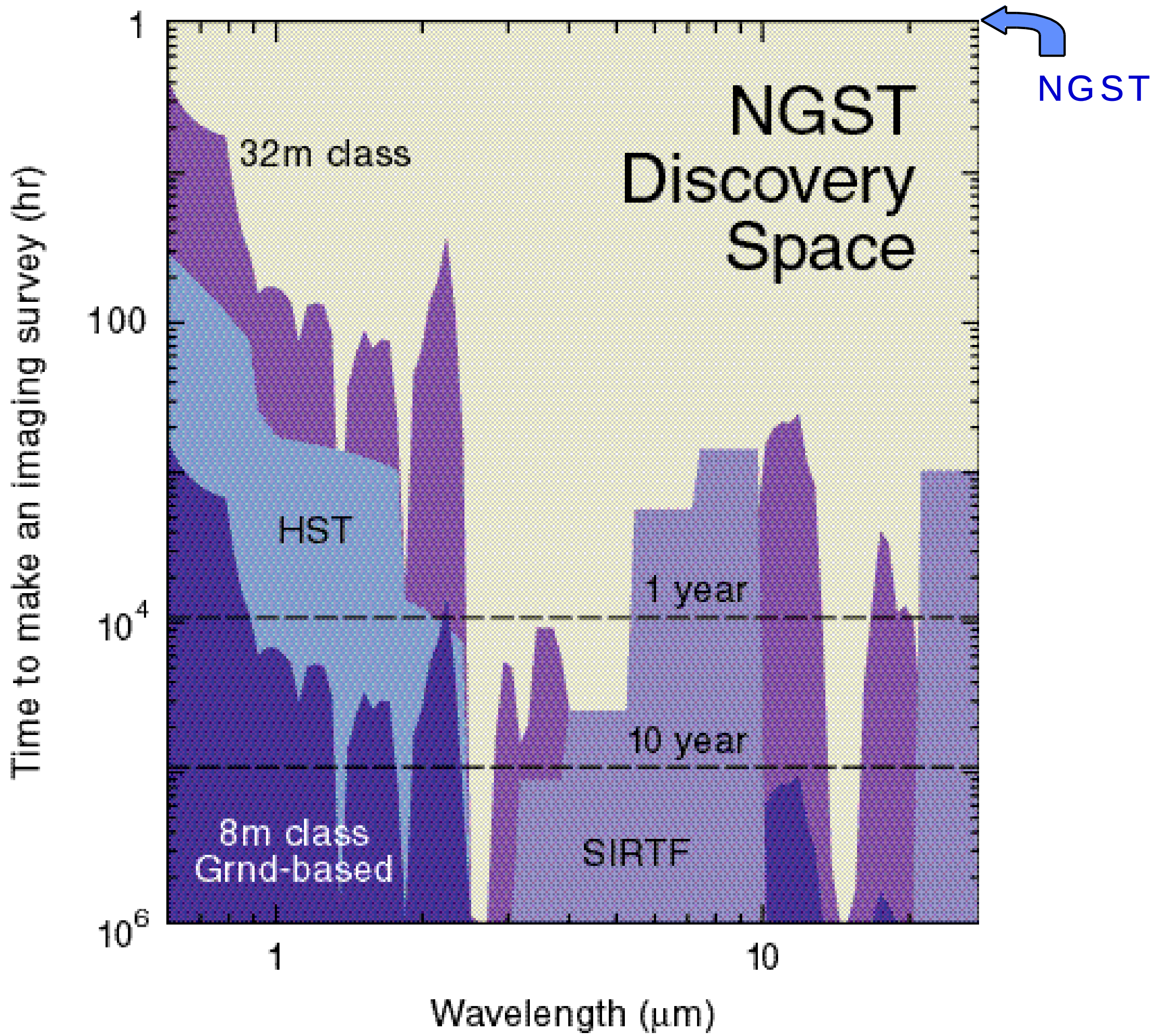
NEXUS tech demo by 2004

- Key features
  - 3 AMSD high-authority active optics (2 deployable)
  - Fixed secondary tower
  - Wavefront sensing and control





Discovery Space for NGST



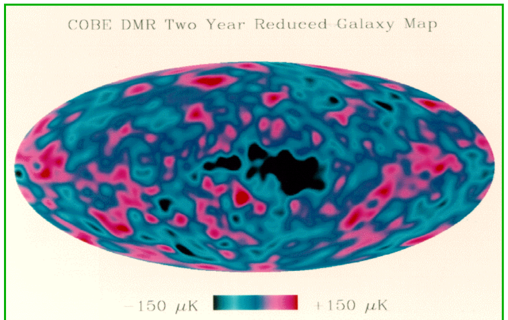
Next Generation Space Telescope

A NASA Origins Mission

NGST & the Early Universe

NGST

$\Delta\rho/\rho \sim 10^{-5}$



Galaxy assembly

Galaxies, stars, planets, life

- When and how do the first stars and galaxies form?
  - Very luminous star forming regions/galaxies at 10^9 yr, z ~ 5.6)
  - New stars forming at constant rate until very recently ($1 < z < 5$)
  - SCUBA sees dust-hidden star formation
- To see the growth of galaxies such as Milky Way, need NGST (0.6-10μm)
  - **Sensitivity** to see the first star formation, (z ~ 10-20, 0.1 nJy)
  - **Angular resolution & wide field** to survey 10^5 protogalaxies (to z ~ 5)
  - **MIR imaging and spectroscopy** to see hidden stars and AGN

The Structure and Chemistry of the Universe

NGST

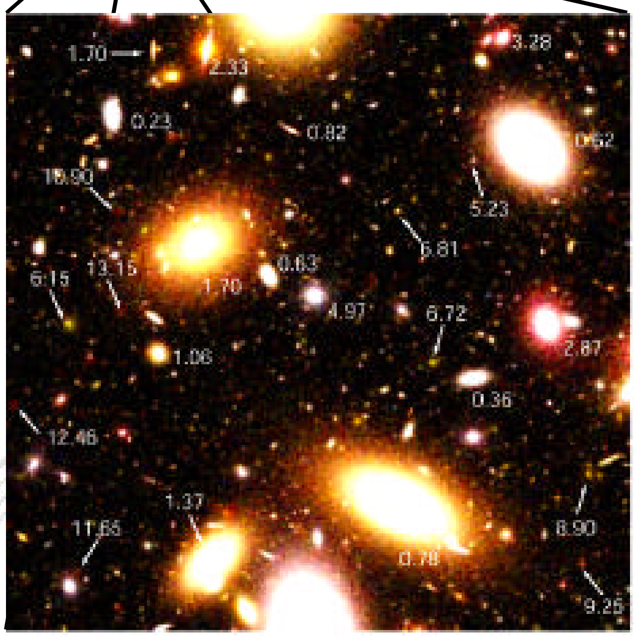
- How did the Universe form? What is it made of?
  - Supernovae support an accelerating universe ($\Lambda \sim 0.8$)
  - Cluster X-rays & strong lensing supports a low density universe ($\Omega \sim 0.2$)
  - CMB missions (MAP, Planck) will measure small scale temperature variations 300,000 years after the Big Bang ($z \sim 1100$) to constrain cosmological parameters (Ω_m, Λ , H_0, S-Z effect)
- NGST provides direct astronomical evidence of the growth of structure and cosmological dimming (at $Z \sim$ 1-5)
  - HST-like resolution, wide field of view enable statistical masses of galaxies, clusters and larger structures on scales from galaxies to galaxy superclusters (from 0.1-10 Mpc, weak lensing)
  - Type Ia and Type II supernovae (to Z>5) provide independent complementary constraints on the expansion and chemical evolution of the Universe
  - *Connects directly with study of early galaxies: distances, masses, luminosities, etc.*

NGST Deep Imaging: 0.5–10 μm

ASWG: Simon Lilly

4'x4' deep survey field

5000 galaxies to AB ~ 28, 10^5 galaxies to AB ~ 34, photometry, morphology & z's

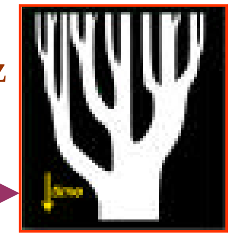


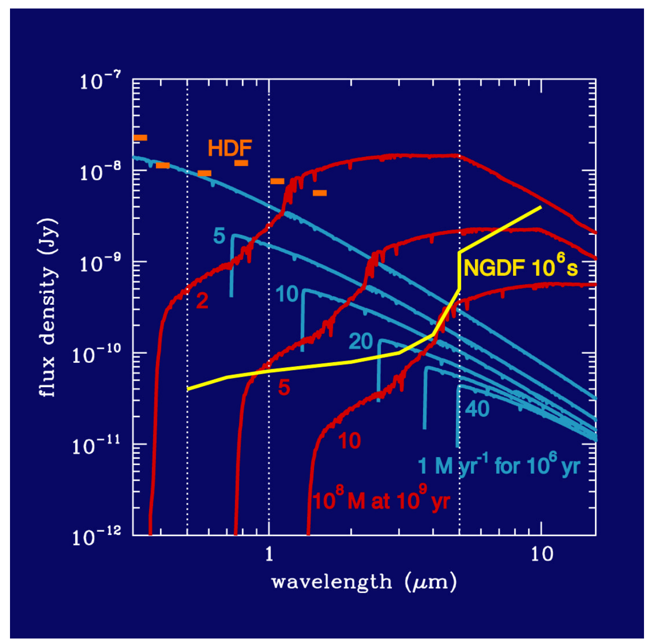
Depth: AB ~ 34 in 10^6 s

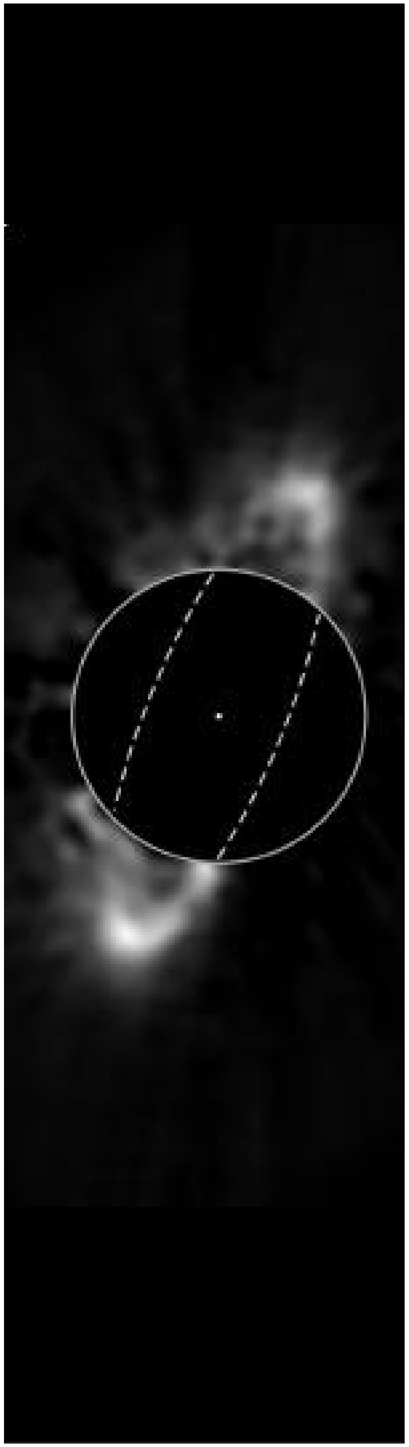
Redshifts: Lyman α to z = 40 (?)

4000 Å to z = 10

NGST will detect 1 M_s yr^{-1} for 10^6 yrs to z ≥ 20 and 10^8 M_s at 1 Gyr to z ≥ 10 (conservatively assuming Ω = 0.2)







The Physics of Star and Planet Formation -- *Making a Home for Life*

- Are planetary systems like our Solar System common? How do they form? Is the chemistry of the Interstellar Medium important in the creation of life?
- To address these complex questions, observations on all scales and many wavelengths must be knit together with theory
- NGST will play an important role with its near- and mid-infrared capabilities by:
  - Determining the physics of star formation: the assembly of stars and proto-planetary disks from cloud cores
  - Imaging and doing atmospheric studies of Jupiter-sized planets at similar (5 AU) distances around nearby stars (50 candidates within 8 pc, needs a simple MIR Lyot stop)
  - Inventorying the prebiotic materials in starforming systems

Evolution of Planetary Systems

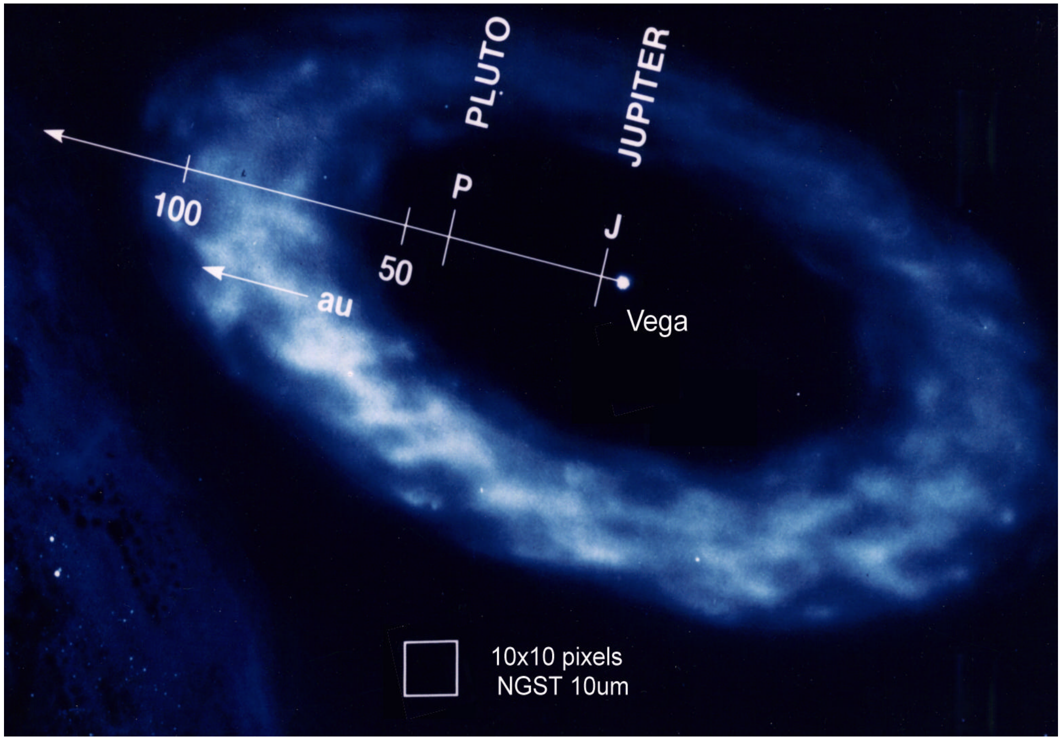
Vega Disk Detection

λ (μm)	Contrast Star/Disk	Flux* (μJy)
11μm	2.4	1.5×10^7
22μm	400	2×10^4

Reflected & emitted light detected with a simple coronograph.

*per Airy disk

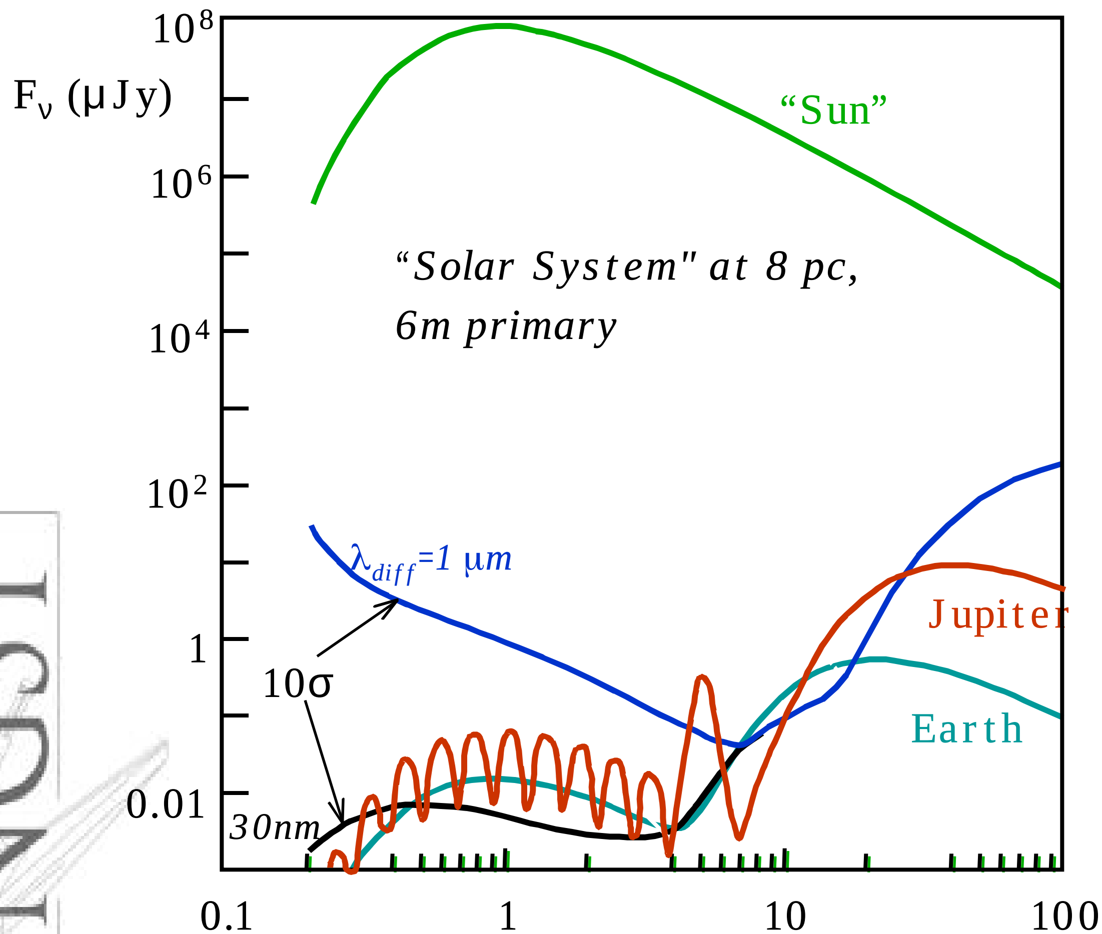
ASWG: Marcia Rieke



NGST resolution at 24μm = 5 AU at Vega, > 10 pixels across the inner hole

NGST, NNGST, & Extrasolar Planets

From Angel & Woolf 1998, in *Science with the NGST*, ASP, **133**, 172



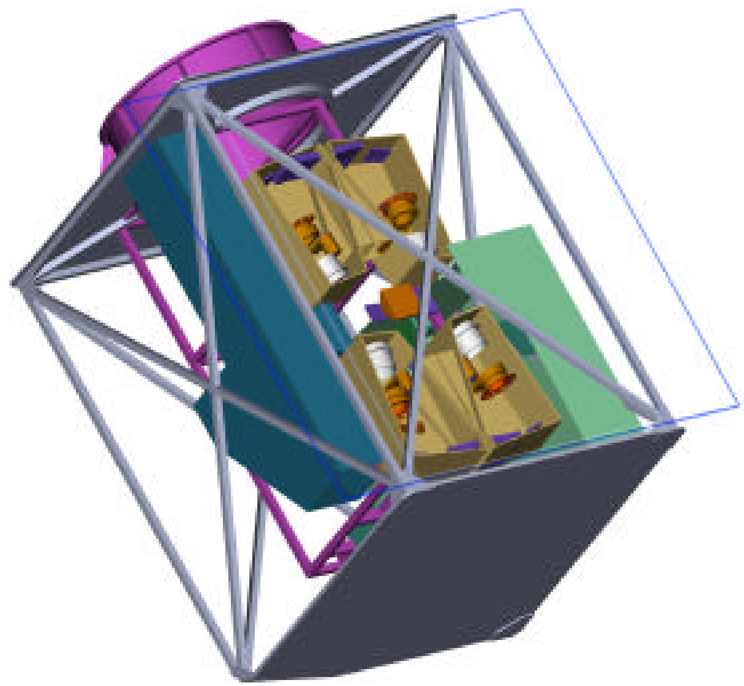
- Control of primary only:
  - Jupiter at 10 < λ < 20 μm
- Active wavefront correction to 30 nm rms
  - Direct detection of Jupiter λ > 0.4 μm

Not a baseline program, but a natural upgrade issue for future missions such as TPF or an NNGST.

Science Instruments

Integrated Science Instrument Module (ISIM) -- cold instrument module and data system

- Objective
  - Procure instruments from US/international science community
  - GSFC to integrate flight qualified science instruments, optics, thermal control, electronics into ISIM, deliver to prime as GFE
- Status
  - 16 studies completed
  - Science Team recommendations
  - International negotiations ongoing



16 Instrument Studies

NGST

Next Generation Space Telescope

NGST

A NASA Origins Mission

- 3 Instrument Suites -- Arizona, ESA, NASA
- 1 NIR Camera -- Colorado
- 3 Imaging FTS -- UC/Berkeley, ESA, CSA
- 3 NIR Spectrographs -- STScI, ESA, CSA
- 2 MIR Camera/Spectrographs -- JPL, ESA
- 2 Visible Cameras -- CSA, ESA
- 2 Coronagraphs -- JPL, ESA

- Study Reports and supporting documents at http://www.ngst.nasa.gov/science/isimpage.html

Recommended Instruments

- 4´ x 4´ NIR Cam (8k x 8k pixels)
  - Nyquist sampled at 2 μm, 0.6-5 μm, R~100 grism mode
    - First light, gal. form, dark matter, SNe, young stars, KBOs, stellar pops
- 3´ x 3´ NIR *R*~1000 MOS
  - Simultaneous source spectra(≥ 100), 1-5 μm
    - Gal form./diag. (clustering, abun., star form., kinematics), AGN, young stellar clusters (IMF/stellar pops)
- 2´ x 2´ Mid IR Cam/*R*~1500 spectrograph
  - Nyquist sampled at ~10 μm, 5-28 μm, grisms & slit
    - Physics of old stars at high redshift, z~5 obscured star form. & AGN to *z* ~ 5, PAH to *z*~5, Hα to z~15 , cool stellar IMF, protostars and disks, KBO sizes, comets

Next Generation Space Telescope

NGST

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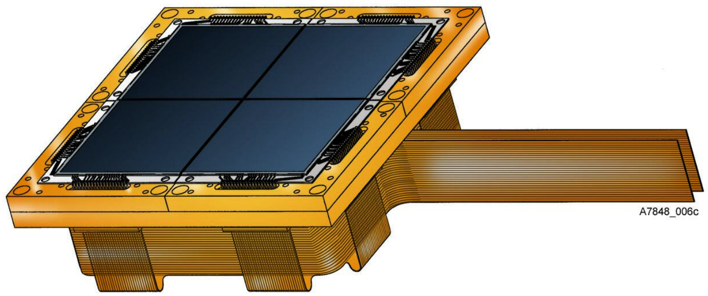
NGST

4th Instruments that would significantly enhance NGST capabilities to meet science goals

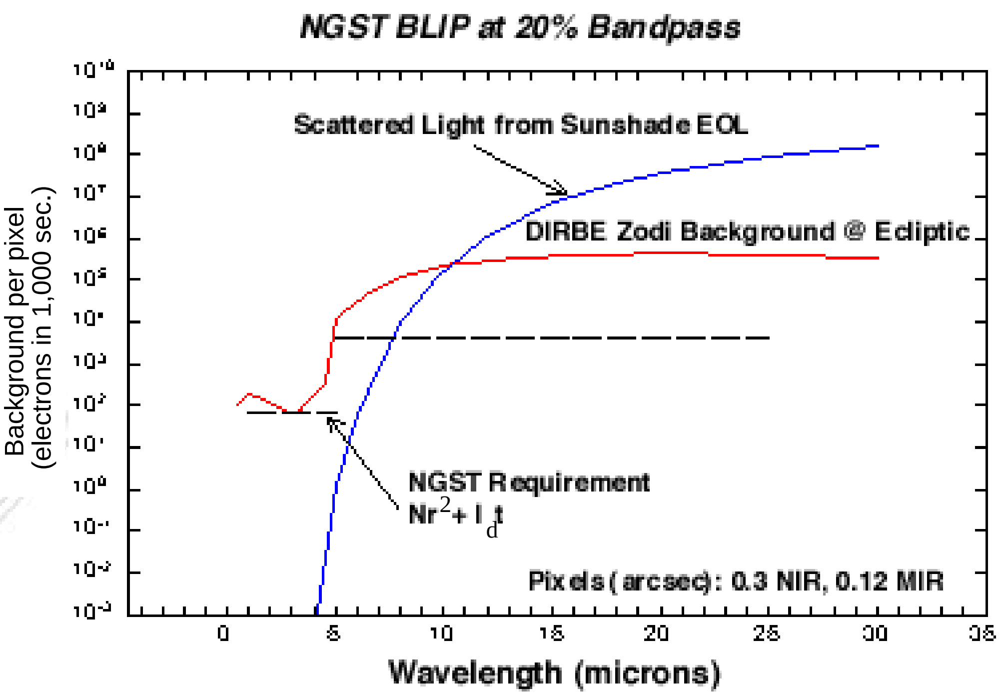
- NIR *R*=3000-5000 psf-sampled spect.
  - ≤0.1´´ angular resolution, ~2´´ x 2´´ FOV
  - 2d for single, extended object spectroscopy
- 0.6 - 1 μm camera (sampling diffraction spike)
  - ~0.01´´ angular resolution, 1´ x 1´ FOV
  - (Note-- assumes NIRCAM has 0.6 μm capability)
  - stellar pops/WD cooling curve, circumstellar disks, high z gal. Morphology
- MIR R=3000-5000 psf-sampled spect.
  - ≤0.3´´ angular resolution, ≥ 2´´ x 2´´ FOV, 5-28.3 μm
  - Instead of R~1500 add-on spectrograph to MIR camera

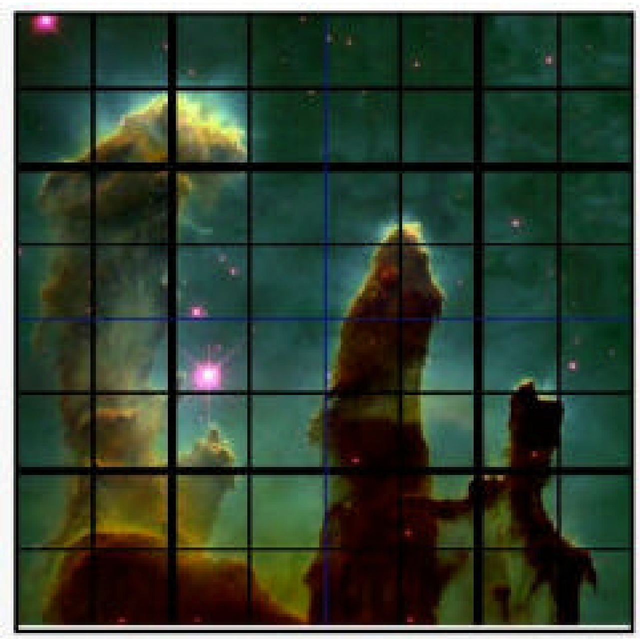
Detector Technology

- Objective -- develop Near IR (0.6 - 5 μm, 4k x 4k) and Mid IR (5 - 10+ μm, 1k x 1k) focal planes
  - Yardstick concept utilizes five 16.8 Mpixel FPAs
- Status
  - 6 competitively selected technology contracts underway
  - Large format cryo readouts and packaging
  - Short λ HgCdTe shows good visible performance (> 50% uncoated)
  - Si:As IBCs show 10% reduction in noise relative to SIRTF



Courtesy of Ball Aerospace





Courtesy of J. Hester, P. Scowen (ASU) & J. Morse (U.CO)

Conclusions

- NGST gives huge advance in observing capabilities
- NGST can observe
  - Acceleration/deceleration of expanding universe
  - Effects of cosmic dark matter
  - First luminous objects after Big Bang, even if much smaller than galaxies
  - Initial creation of heavy elements
  - Protogalaxies merging into large galaxies
  - First release of dust from first stars
  - Deep into active galactic nuclei
  - Individual stars in distant galaxies
  - Interstellar gas and dust
  - Recent formation of stars and planets
- It's very difficult but well worth the effort